1916
B98

Buxton.

Method Of Execution Of Philippine Cadastral Surveys.

METHOD OF EXECUTION

OF

PHILIPPINE CADASTRAL SURVEYS

BY

EDWIN WALKER BUXTON

B. S., UNIVERSITY OF ILLINOIS, 1907

THESIS

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE

DEGREE OF

CIVIL ENGINEER

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1916

TABLE OF CONTENTS.

	Page.
INTRODUCTION	1
I. PRIMARY TRAVERSE	5
Description of Stations	5
Location	6
Equipment of Chaining Party	6
Method of Chaining	6
Determination of Azimuths	8
Balancing the Traverse	10
II. SECONDARY TRAVERSE	17
Description of Stations	17
Equipment of Field Party	17
Method of Execution	18
Balancing the Traverse	18
III. SKETCHING	20
Personnel	20
Methods	20
Free-hand	20
Plane-table	21
Office Work	21
IV. MONUMENTING	22
Method	22
Number Required	22
V. TERTIARY SURVEY	27
Equipment and Personnel of Field Party	27
Notification of Survey	28

TABLE OF CONTENTS (Cont'd.)

V. TERTIARY SURVEY (Cont'd.) Page

Method of Execution. 28

Marking of Lot Corners 30

Balancing the Traverse 30

Monthly Rate 31

Previously Surveyed Properties 31

Difficulties Encountered 32

VI. POLITICAL BOUNDARIES 43

Location 43

Monumenting. 44

VII. THE FIELD OFFICE 47

Personnel 47

Office Functions 47

VIII. GENERAL INFORMATION AND COSTS. 53

Project Personnel. 53

Costs 54

General Information. 55

IX. SUMMARY. 56

LIST OF ILLUSTRATIONS.

Fig.	Subject	Page
1.	Primary Monuments.	5
2.	Rear Instrument and Tape Stretcher	14
3.	Forward Instrument	14
4.	Near View of Clinometer and Stretcher.	15
5.	Chaining Party	15
6.	Target Used on Triangulation Stations.	16
7.	Target Used on Stations of Primary Traverse.	16
8.	Spike in a Cross on a Tree Used as Lot Corner.	24
9.	Getting Gravel from River Bed for Monuments.	24
10.	Monument Forms Assembled.	25
11.	Lot Corner Monuments Ready for Distribution	25
12.	Field Office, Project Survey Headquarters	37
13.	Surveyor's Temporary Field Quarters	37
14.	Tertiary Party Going to Work	38
15.	Tertiary Party	38
16.	Tertiary Party at Work	39
17.	Tertiary Party at Work	39
18.	Character of Country Surveyed.	40
19.	Character of Country Surveyed.	40
20.	Character of Country Surveyed.	41
21.	Character of Country Surveyed.	41
22.	Character of Country Surveyed.	42
23.	Character of Country Surveyed.	42
24.	Provincial Monument Form	45
25.	Provincial Monument	45

Digitized by the Internet Archive
in 2014

http://archive.org/details/methodofexecutio00buxt

LIST OF ILLUSTRATIONS (Cont'd.)

Fig.	Subject	Page
26.	Municipal Monument.	46
27.	Barrio Monument	46
28.	Index Map.	52
29.	Map Sheet.	52

LIST OF FORMS

	Page
Sample Page from Primary Chain Book	11
Page of Solar Observation Notes.	12
Solar Observation Computation . . . Following	12
Page from Primary Angle Book	13
Numerical Index Card	26
Page of Tertiary Notes	35
Alphabetical Index Card.	36
Notification of Survey Card.	36
Tertiary Traverse Computation. . . . Following	52
Area Sheet . . . . . "	52
Progress Map . . . . . "	52

METHOD OF EXECUTION

OF

PHILIPPINE CADASTRAL SURVEY.

INTRODUCTION.

Previous to the American occupation of the Philippine Islands only a small number of surveys had been made and these mainly inaccurate. Since the American occupation but previous to the passage of the Cadastral Act a greater number of surveys had been made under the existing laws. These surveys were, however, isolated and were, as a rule, prohibitive to the average property holder on account of their cost. To remedy this condition the Cadastral Act, No. 2259, was passed by the Third Philippine Legislature on February 11, 1913. It was the result of a recognized and increasing need for legislation which would authorize the survey and registration, at one time, of all lands within a given district. This law provides; that three-tenths of the cost of such survey and adjudication be shared equally by the Insular Government, the Province, and the Municipality; that the remaining seven-tenths be paid in five equal annual installments, as taxes, by the individual property holders to whom titles are issued; and that no apportionment of any part of the cost of the survey be made against properties which have previously been surveyed by an authorized surveyor, nor any apportionment of any part of the cost of the survey, monumenting, and registration be made against any properties

previously registered in the Court of Land Registration.

The author has been in the Philippine Service for the last seven years, from 1908-16, four years of this time were spent in the execution of miscellaneous surveys, and since the passage of the Cadastral Act has been in charge of the Survey of several Cadastral projects. Acknowledgement of the valuable assistance of Mr. J. W. Evans in the preparation of this thesis is made, he, in fact, presenting a similar thesis at Purdue University in partial fulfillment of the requirements for a C. E. degree.

With regard to the benefits to be derived from the Cadastral Act the following is quoted from the Report of the Director of Lands for the fiscal year ending June 30, 1913:

> "While it cannot be predicted exactly what the effect of the Cadastral Survey Law will be, it is believed that it will reduce the cost for registration of title, including the cost of survey, attorneys fees, etc., by at least one-half; it will segregate private from public domain; it will give Insular, provincial, and municipal officials plans of municipalities, barrios, and sitios, including the boundaries thereof, roads, streams, etc., and the actual boundary of each private land holding with its area. This in turn should materially affect the land taxes and provide means whereby no land will escape taxation, at least so far as the ownership and area is concerned, and it is believed that the average increase will be about 25 per cent in the land tax assessed, ----."

The Cadastral unit generally chosen for survey and adjudication is the municipality, which is a subdivision of the province. A request for such survey originates, as a rule, in the municipality and is approved by the Provincial Board. This request is then forwarded to the Governor-General, who instructs the Director of Lands to execute a survey of the municipality.

The Director of Lands thereupon appoints a surveyor to take charge of the survey, or Cadastral project, as it is called; fixes a date for the commencement of the survey; and advertises it in conformity to law.

The conduct of the work is, briefly, as follows:

The surveyor and his assistants proceed to the municipality which is to be surveyed and secure suitable quarters for office and domicile. A reconnaissance of the approximate boundary of the project is then made with a view to the location of the primary traverse, and notices of survey in English and Spanish are posted at various places within the municipality at this time. The primary traverse, following approximately the boundary, is then executed, establishing an accurate control for the project. Additional control is then provided by running secondary lines which traverse and subdivide the area. All lots are then sketched and monumented, this process being closely followed by the tertiary survey, which is the actual survey of the property boundaries.

On the map of each island latitude and longitude lines are plotted two minutes apart. Each of the squares so formed is then numbered, and map sheets, to a scale of 1 to 4000, are prepared as needed for each number.

Each project is a unit in itself, is treated as a plane surface, and the position of each point in it is indicated by its co-ordinates on a rectangular system. The origin of co-ordinates is a previously located monument in the principal town of the municipality, and co-ordinates of North 20,000 meters and East

20,000 meters are usually assigned to this monument. The metric system is used for all land surveys in the Philippine Islands.

The survey of a project is dealt with in detail in the following pages.

I. PRIMARY TRAVERSE.

The primary traverse is an accurate determination of the position of a line of monuments circumscribing the area being surveyed. Its purpose is to supply the need for permanent marks which can be used as starting points for secondary and tertiary traverses for the survey of the lands in their vicinity. The length of the primary traverse line depends upon the size and shape of the project being surveyed, but is ordinarily between twenty and eighty kilometers.

DESCRIPTION OF STATIONS. The stations of the primary traverse are marked by cylindrical concrete monuments, ten centimeters in diameter by fifty centimeters long, centered with a galvanized iron spike, and marked with the letter P and the number of the monument. Numbers are assigned to the stations from one,

Fig. 1. Primary Monuments.

consecutively in a clock-wise direction around the traverse.

LOCATION. The primary traverse line starts from primary monument No. 1 which is the origin of co-ordinates, and is one of a pair of location monuments in the principal town of the project. It follows approximately the boundary of the project and closes on the starting point. The distance between stations is usually greater than one hundred meters and less than one thousand, as lengths outside of these limits are conducive to inaccurate or expensive measurement of angles and distances. In locating the primary traverse stations, it is necessary to avoid obstructions such as steep hills, ravines, growing crops, swamps, timber, heavy grass, and country liable to inundation. To accomplish this, public and private roads are utilized wherever possible. Where mountain tops form the project boundary, the traverse is run only to the base of the foot-hills, so as to include practically all cultivated or non-forested land.

EQUIPMENT OF CHAINING PARTY. The equipment of the primary chaining party consists of a steel tape, two line clinometers, two tape stretchers, a spring balance, two field umbrellas, three range poles for tape supports, two thermometers, one stadia rod, and a small band tape graduated to millimeters. The personnel consists of two surveyors and a sufficient number of native laborers to carry the equipment. Twelve laborers suffice where there are few obstructions to be cleared out of the line.

METHOD OF CHAINING. Chaining is usually done with a new one-hundred meter, one-eighth inch wide, Keuffel & Esser or Lucas steel tape, standardized by the U. S. Bureau of Standards, and the tape constants are furnished the field party. For the correct

determination of the vertical angle at which a measurement is made, line clinometers are used. Temperature readings are taken at two points along the tape for each measurement, and care is exercised so to expose the thermometers that they may indicate the actual temperature of the tape. Correct tension is applied by means of the tape stretchers and a spring balance. The method of measuring primary distances is, in general, as follows: One line clinometer is set over a primary station, leveled, and sighted at the stadia rod on the next station. The other instrument is then set on line at a distance of approximately one hundred meters, each instrument is sighted on the telescope of the other, and intermediate tape supports at the 25, 50 and 75 meter points are given the proper line and elevation. The spring balance and stretchers are attached to the tape, the correct tension is applied by the rear stretcher while the other stretcher holds the zero of the tape at the vertical axis of the forward instrument, and the distance is read at the rear instrument. The distance, vertical angle, and temperatures are recorded, and the rear clinometer is moved forward two hundred meters while the instrument men move ahead one hundred meters and repeat the operation. The fractional tape length at the end of a line is measured in a similar manner excepting that such intermediate supports as are not needed are omitted.

The tape supports on the line clinometers are about one meter high and in chaining no point of the tape is allowed to be nearer than fifty centimeters to the ground. In measuring over rough country and between short stations, the work is retarded by the greater number of set-ups required. The length of line measured

per day depends upon the topography, length of stations, obstructions encountered, and distance from living quarters. Under average conditions from four to five kilometers are measured per day, but along good roads seven or eight kilometers are often chained.

All distances are measured twice, and after the proper corrections are made for temperature, vertical angles, and chain constant, the difference between the two measurements for each station distance must be less than one in 20,000 of their mean. A third measurement, necessitated by failure to meet this requirement, is seldom made, because this difference is usually less than one in 40,000.

On page 11 is shown a sample page from the primary chain book.

DETERMINATION OF AZIMUTH. At least four series of solar observations, two in the morning and two in the afternoon, are taken to determine the true azimuth of the pair of location monuments from which the primary traverse starts. A series of solar observations consists of four sets, two taken with the telescope direct, and two reversed. The resulting azimuth of each of these four sets must not differ by more than 30" from any of the others. The average of the four sets must be within 20" of similar averages of each of the other three series. The true meridian thus derived at the location monuments is designated the "base meridian" to which all azimuth readings in the project are referred.

On page 12 is shown a sample page of solar observation notes and between pages 12 and 13 a sample Solar observation computation.

Solar observations, and horizontal angle measurements at the primary stations, are taken with six-inch thirty-second Berger transits adjusted as carefully as possible. Atmospheric conditions usually require that the angular measurements be made in the early forenoon or late afternoon, especially in the dry season when the heat waves, wind, and dust make sighting very difficult. Each angle is measured by repetition, six times with the telescope direct and six times reversed. Before the first measurement the vernier is set at zero, and besides this reading, only the first, sixth, and twelfth are read and recorded. If the twelfth reading is not within 30" of 360 degrees, the whole series is repeated. The closing error, if any exists, is distributed equally between the interior and exterior angles at that point. The field azimuth of each course is obtained by combining this repeated angle with the reversed azimuth of the preceding course, the original azimuth used being that obtained from the solar observations over the location monuments. When the angular error of closure of the traverse has been determined, it is distributed uniformly among the courses.

On page 13 is shown a sample page from the primary angle book.

The true azimuth at each of the four corners of the primary traverse is determined by solar observations. These azimuths are modified by applying the angular convergence between these points and the base meridian. The results so obtained should then be found to agree closely with the azimuths deduced from the repetition angular readings. If a discrepancy greater than 20" is

found to exist, the azimuth observations are first verified, and if found correct the angles are reread.

BALANCING THE TRAVERSE. When the requirements for angle and distance measurements are fulfilled, the traverse is balanced in azimuth to the nearest 5" of arc at each station. The mean of the reduced chainings is taken and the latitudes and departures are computed with seven place logarithms to the nearest millimeter, and the lineal error of closure is determined.

The circuit is required to close on itself with a maximum error of $A = 1/224\sqrt{P}$, in which A is the allowable error of closure and P is the perimeter. This formula is based upon the law of the probability of errors and upon the assumption that the measure of precision is 1 in 50,000. In case the error of closure is in excess of the amount allowed, the circuit is divided approximately in half by a new primary and the two sections are computed separately to determine the location of the error. The circuit in which the greater error is found is again divided and remeasured until the error is found and eliminated.

Latitudes and departures are then balanced and the coordinates of the traverse stations computed.

B. L. Form No. 199.

over

	Corrected Tape Lengths.	Vertical Angle.	Corrected to Horizontal.	
				See page
				Primary Angle
				Book for Azimuth
				Spring Balance
				Correction=
				Thermometer Correction
				A=
				B=
				Corrected Distance "C"
				"C"=
				"D"=
				Sum 2)_____
				Mean="E"
				Discrepancy $=\frac{\text{"C"}-\text{"D"}}{\text{"E"}}=\frac{1}{\quad}$
				Corrected Distance "D"

It is reserved for binding.

over

Sample Page from Primary Chain Book.

DISTANCE P , TO P , , 191

TAPE READINGS.	THERMOMETER READINGS. A 25 M.	THERMOMETER READINGS. B 75 M.	AMT. CORRECTION FOR— TEMPERATURE.	SAG.	TENSION.

Observed by , Standard Tape #

Supported at M. Intervals. Tension Kilos.

Distance P , to P , , 191

TAPE READINGS.	THERMOMETER READINGS. A 25 M.	THERMOMETER READINGS. B 75 M.	AMT. CORRECTION FOR— TEMPERATURE.	SAG.	TENSION.

Observed by , Standard Tape #

Supported at M. Intervals. Tension Kilos.

Do not write on this margin.

B. L. Form No. 199.

Corrected Tape Lengths.	Vertical Angle.	Corrected to Horizontal.	
			See page
			Primary Angle
			Book for Azimuth
			Spring Balance
			Correction=
			Thermometer Correction
			A=
			B=
			Corrected Distance "C"
			"C"=
			"D"=
			Sum 2)
			Mean="E"
			Discrepancy ="C"–"D"="E" 1
			Corrected Distance "D"

It is reserved for binding.

Sample page from primary chain book

Sample Page from Primary Chain Book.

B. L. Form No. 94a.

over

SKETCHES, DESCRIPTIONS, AND REMARKS.

Corrected Azimuth.	Corrected Distance.	

It is reserved for binding.

over

Sample Page of Solar Observation Notes.

2—231

Sta. Occupied.	Sta. Observed.	Stadia Distance.	Assumed Azimuth.	Chain Distance.	Magnetic Bearing.	Vertical Angle.	

Do not write on this margin.

B. L. Form No. 94a.

SKETCHES, DESCRIPTIONS, AND REMARKS.

Corrected Azimuth.	Corrected Distance.	

It is reserved for binding.

Sample solar Observation notes

Sample Page of Solar Observation Notes.

B. L. Form No. 58.

B. L. Survey No. .....

BUREAU OF LANDS.

AZIMUTH COMPUTATION FROM SOLAR OBSERVATIONS.

Divide by	4
Average Azimuth, Station to Mark	54 37 67 21 09
True Bearing, Station to Mark	S 67 21 09 W
Magnetic Bearing, Station to Mark	S 54 55 00 W
Magnetic Declination	2 06 E

If Mark is to left of Sun, horizontal angle is to be subtracted; if to right, it is to be added.

Give magnetic declination to nearest minute.

Data observed by H H Houk.

Data recorded by Manuel Lizo

Data copied by E. Ibañez Apr. 13, 1915

Computed by C Generoso Apr 16, 1915

Checked by E. Ibañez Apr 17, 1915

CORRECTION FOR LONGITUDE IN TIME. *If Local Mean Time is used, add 4 min. for each degree East of 120 meridian. Subtract 4 min. for each degree West of 120 meridian.*

Lines 7 and 8 not to be used if observer has 120 meridian time.

Sample solar observation computation

					First Term
					Second Term
					Log second Term
					Log Tan H
					Log Tan L
					First Term
					Log first Term
					Co log Cos H
					Co log Cos L
					Log Cos. P
					14 Corr. N. Polar Dist.=P

B. L. Form No. 68. B. L. Survey No.

BUREAU OF LANDS.

AZIMUTH COMPUTATION FROM SOLAR OBSERVATIONS.

Latitude, ° ′ ″ N.; Longitude, ° ′ ″ E.

Surveyed for Date, , 191

Cot. ½ A = √ Sec. S, Sec. (S − P), Sin. (S − H), Sin. (S − L).

Where A is the angle between South and Sun.
P is the North Polar Distance of Sun (90 ± Declination).
H is the altitude of Sun, corrected for Refraction.
L is the Latitude of Station.
S is ½ (P + H + L).

WATCH TIME USED.

Local Mean Time.
120th Mer. Time.
Watch min { slow / fast } for time specified above.

Station occupied,

Station observed or mark
(Mark must be described.)

Assumed Azimuth from Station to Mark

		Set I, Direct. Time. Time.		Set II, Reversed. Time. Time.		Set III, Reversed. Time. Time.		Set IV, Direct. Time. Time.	
		Horizontal Angles.	Vertical Angles.	Horizontal Angles.	Vertical Angles.	Horizontal Angles.	Vertical Angles.	Horizontal Angles.	Vertical Angles.
1	(1) Readings								
2	(2) Readings								
3	Sums								
4	Mean								
5	Parallax and Refraction								
6	True Altitude=H								
7	Local M. Time of observation								
8	Correction for Longitude in time								
9	120 Meridian Time								
10	Diff. in hrs. from { 7 A. M. / 8 P. M. }								
11	Hourly difference								
12	Total difference								
13	N. Polar Dist. from Table								
14	Corr. N. Polar Dist.=P								
	H								
	L								
	2 S								
	S								
	P								
S−P									
	S								
	H								
S−H									
	S								
	L								
S−L									
Log. Sec.	S								
Log. Sec.	S−P								
Log. Sin.	S−H								
Log. Sin.	S−L								
Log. Cotan.²	½ A								
Log. Cotan.	½ A								
½ A									
A									
Azimuth of Sun									
Angle Sun to Mark									
Azimuth, Station to Mark									
Azimuth, Set II									
Azimuth, Set III									
Azimuth, Set IV									
Divide by	4								
Average Azimuth, Station to Mark									
True Bearing, Station to Mark									
Magnetic Bearing, Station to Mark									
Magnetic Declination			E						

In A. M. Azimuth of Sun is 360° minus A.
In P. M. Azimuth of Sun is A.
If Mark is to left of Sun, horizontal angle is to be subtracted; if to right, it is to be added.

Give magnetic declination to nearest minute.

Data observed by
Data recorded by
Data copied by , 191
Computed by , 191
Checked by , 191

CORRECTION FOR LONGITUDE IN TIME. If Local Mean Time is used, add 4 min. for each degree East of 120 meridian. Subtract 4 min. for each degree West of 120 meridian.

Lines 7 and 8 not to be used if observer has 120 meridian time.

Sample solar observation computation

B. L. Form No. 58. B. L. Survey No.

MANILA OFFICE ONLY.

Latitude, ″ *N.; Longitude,* ′ *E.*

Surveyed for *Date,* , 191

2—124

Cos. A $= \frac{\text{Cos. P.}}{\text{Cos. L. Cos. H.}} - \text{Tan. L. Tan. H.}$

Where A = Sun's Azimuth from South.

P is the North Polar Distance of Sun (90° ± Declination).

H is the altitude of Sun, corrected for Refraction.

I, is the Latitude of Station.

Station occupied.

Station observed or mark

(Mark must be described.)

	Assumed Azimuth from Station to Mark	Set I, Direct. — Time.		Set II, Reversed. — Time.		Set III, Reversed. — Time.		Set IV, Direct. — Time.	
		Horizontal Angles.	Vertical Angles.	Horizontal Angles.	Vertical Angles.	Horizontal Angles.	Vertical Angles.	Horizontal Angles.	Vertical Angles.
1	(1) Readings								
2	(2) Readings								
3	Sums								
4	Mean								
5	Parallax and Refraction								
6	True Altitude=H								
7	Local M. Time of observation								
8	Correction for Longitude in time								
9	120 Meridian Time								
10	Diff. in hrs. from { 7 A. M. / 3 P. M.								
11	Hourly Difference								
12	Total Difference								
13	N. Polar Dist. from Table								
14	Corr. N. Polar Dist.=P								
	Log Cos. P								
	Co log Cos L								
	Co log Cos H								
	Log first Term								
	First Term								
	Log Tan L								
	Log Tan H								
	Log second Term								
	Second Term								
	First Term								
	Second Term								
	Nat Cos. A								
	Angle A								
	Azimuth, Station to Mark								
	Azimuth, Set II								
	Azimuth, Set III								
	Azimuth, Set IV								
	Divide by	4							
	Average Azimuth, Station to Mark								
	True Bearing, Station to Mark								
	Magnetic Bearing, Station to Mark								
	Magnetic declination			*Give magnetic declination to nearest minute.*					

Data observed by

Data recorded by

Data copied by , 191

Computed by , 191

Checked by , 191

B. L. Form No. 58.

B. L. Survey No. _____

MANILA OFFICE ONLY.

Latitude, _____° _____′ _____″ *N.; Longitude,* _____° _____′ _____″ *E.*

Surveyed for _____ *Date,* _____, *191*

2—124

$$\text{Cos. } A = \frac{\pm \text{ Cos. } P.}{\text{Cos. } L. \text{ Cos. } H.} - \text{Tan. } L. \text{ Tan. } H.$$

Where A =Sun's Azimuth from South.

P is the North Polar Distance of Sun (90°± Declination).

H is the altitude of Sun, corrected for Refraction.

L is the Latitude of Station.

Station occupied, _____

_____

Station observed or mark _____

(Mark must be described.)

	Assumed Azimuth from Station to Mark _____	Set I, Direct. ○ Time. — ○ Time.		Set II, Reversed. ○ Time. — ○ Time.		Set III, Reversed. ○ Time. — ○ Time.		Set IV, Direct. ○ Time. — ○ Time.	
		Horizontal Angles.	Vertical Angles.	Horizontal Angles.	Vertical Angles.	Horizontal Angles.	Vertical Angles.	Horizontal Angles.	Vertical Angles.
1	(1) Readings								
2	(2) Readings								
3	Sums								
4	Mean								
5	Parallax and Refraction		—		—		—		—
6	True Altitude=H								
7	Local M. Time of observation								
8	Correction for Longitude in time								
9	120 Meridian Time								
10	Diff. in hrs. from { 7 A. M. / 3 P. M. }								
11	Hourly Difference								
12	Total Difference								
13	N. Polar Dist. from Table								

B. L. Form No. 198.

E. of C. Correction.

Corrected Angles.

18

″ ° ′ ″

2nd ∠

″ ° ′ ″

1st ∠

360° 00′ 00″

Field Azimuth Preceding Line

± 180

Back Azimuth P to P

± Angle

Field Azimuth

± Circuit Closure Correction

Corrected Azimuth

It is reserved for binding.

″ ° ′ ″

2nd ∠

″ ° ′ ″

1st ∠

360° 00′ 00″

Field Azimuth Preceding Line

± 180

Back Azimuth P to P

± Angle

Field Azimuth

± Circuit Closure Correction

Corrected Azimuth

Sample Page from Primary Angle Book.

Survey

2—124

Cos. A =

Where A

P

H

L

1 (1) Readings
2 (2) Readings
3 Sums
4 Mean
5 Parallax and
6 True Altitud
7 Local M. Time of observation
8 Correction for Longitude in time
9 120 Meridian Time
10 Diff. in hrs. from { 7 A. M. / 3 P. M.
11 Hourly Difference
12 Total Difference
13 N Polar Dist from Table

ASSUMED

STATION TO

2—556

	STA. OBSERVED.	TELESCOPE.	NUMBER REPETITIONS.	ANGLE VERNIER A.	ERROR OF CLOSURE.
				° ′ ″	″
2nd ∠	P	R	6		
	P	D	6	° ′ ″	
1st ∠	P	D	1	° ′ ″	
	P	D		0° 00′ 00″	

OBSERVED BY _____ DATE _____, 191

TRANSIT NO.

MAGNETIC BEARING TO P

STATION OCCUPIED P

Mean distance, corrected for tension, temperature, sag, and inclination

P _____ to P _____, _____ Meters.

See page _____ Primary Chain Book.

				° ′ ″	″
2nd ∠	P	R	6		
	P	D	6	° ′ ″	
1st ∠	P	D	1	° ′ ″	
	P	D		0° 00′ 00″	

MAGNETIC BEARING TO P

STATION OCCUPIED P

Mean distance, corrected for tension, temperature, sag, and inclination

P _____ to P _____, _____ Meters.

See page _____ Primary Chain Book.

Do not write on this margin.

_____, 191

d.)

V, DIRECT.

TIME. | TIME.

L

VERTICAL ANGLES.

B. L. Form No. 198.

E. of C. Correction.

Corrected Angles.

" ° ' "

" ° ' " 2nd ∠

" ° ' " 1st ∠

360° 00′ 00″

Field Azimuth Preceding Line

± 180

Back Azimuth P to P

± Angle

Field Azimuth

± Circuit Closure Correction

Corrected Azimuth

It is reserved for binding.

" ° ' "

" ° ' " 2nd ∠

" ° ' " 1st ∠

360° 00′ 00″

Field Azimuth Preceding Line

± 180

Back Azimuth P to P

± Angle

Field Azimuth

± Circuit Closure Correction

Corrected Azimuth

Sample page from primary angle book

Sample Page from Primary Angle Book.

Clinometers Used in Primary Traverse.

Fig. 2. Rear Instrument and Tape Stretcher.

Fig. 3. Forward Instrument.

Fig. 4. Near View of Clinometer and Stretcher.

Fig. 5. Chaining Party.

Fig. 6. Target Used on Triangulation Stations.

Fig. 7. Target Used on Stations of Primary Traverse.

II. SECONDARY TRAVERSE.

A secondary traverse is an accurate measurement of angles and distances between a series of stations running from one primary station to another. Its purpose is to provide an accurate control for the sketching and tertiary survey. It is found best to place a line of secondaries across each map sheet, thus dividing the project into strips about four kilometers wide. However, in districts where the lots are small these lines are placed more closely together.

DESCRIPTION OF STATIONS. Each secondary station is marked by a hard wood stake five centimeters square by fifty centimeters long, centered by a tack, or by a concrete monument of about the same dimensions, molded and set in a bamboo joint. The distance between secondary stations must not exceed three hundred meters. Their location is governed by the same principles that apply in locating the primary stations, but as secondary lines are required in all parts of the project, it is frequently impossible to avoid swamps, hills, timber, or other locations unfavorable to accurate measurement.

EQUIPMENT OF FIELD PARTY. Although the methods employed in measuring secondary traverses differ considerably in different parties, the equipment of the field party usually consists of a thirty-second Berger transit, a field umbrella, two one hundred meter tapes, two range poles, two stadia rods, a spring balance, and a thermometer. The surveyor requires ten or more assistants, the number depending upon the topography and the vegetation that has to be cleared from the line.

METHOD OF EXECUTION. Azimuth is taken from two primary stations and is carried on the secondary line by backsight and foresight readings to the primary on which the secondary traverse closes. Readings are recorded to the nearest 15". The allowable angular error of closure is 15" $\sqrt{N}$, where N is the number of angle readings. The total error is divided into units of 15" and distributed uniformly among the recorded azimuths.

Chaining in level country is quite satisfactorily done by native laborers, but to insure against errors, two sets of chainmen, working independently, are employed. They usually obtain results that differ by less than one in 8,000. Each tape is tested before being sent into the field, spring balances are used to insure a uniform tension, intermediate supports are provided, and temperature readings are taken for each tape length. Vertical angles are read and recorded for measurements where the slope of the tape is more than 15', and in rough country it is necessary to read the vertical angle for each tape length. To obtain these angles it is necessary to set the transit at intermediate points between stations which have a greater length than two hundred meters. The length of line measured per day varies from two kilometers where the country is rough and vegetation heavy, to ten kilometers along good roads.

BALANCING THE TRAVERSE. After angular errors are distributed and chain distances are corrected for slope, temperature, and chain constants, the traverse is computed in the field office. The traverse is then balanced to agree with the co-ordinates established for the primary traverse and must close between primary stations

with an error of less than $1/89\sqrt{P}$, where P is the length of the secondary traverse. Any error in excess of this amount is located and corrected before the line can be finally balanced and co-ordinates assigned to the stations.

When the secondary traverses are completed, the project is surrounded and crossed by a series of lines of monuments whose co-ordinates are accurately determined, and no part of the area to be surveyed is more than two or three kilometers from some such monument.

III. SKETCHING.

As soon as the primary and secondary traverses have progressed sufficiently to be plotted, the lot sketching is begun. Sketch sheets are prepared on mounted drawing paper, one-half the size of the regular map sheets, to a scale of 1:4000 for farm lands and 1:2000 for towns. Co-ordinate lines, primary and secondary traverse lines, and, in most cases, previously surveyed properties are plotted on these sketch sheets before being given to the sketchman.

PERSONNEL. Sketching is done by natives of the middle class, above the average in intelligence, who have received a few years instruction in the graded schools, and who are trained in their duties by the surveyors.

METHODS. Two methods of sketching are in use, which may be designated as the free-hand method and the plane-table method. The former, which is by far the more economical, is at present employed only in projects where there are large holdings, as in sugar cane districts; while the latter method is in general use.

FREE-HAND METHOD. The equipment of a free-hand sketchman consists of a sketch sheet, a small box compass, a hand-axe, scale, and leather field bag. He is assisted by two or three laborers. He begins his work at one of the primary or secondary monuments shown on the sheet he is to sketch, and calls on the neighboring land owners, as he needs them, to show him their boundaries. Distances are estimated and plotted to scale on the map, and directions are obtained by means of the compass. The sketchman's judgment of distances and directions is assisted by the co-ordinate lines and

by the primary and secondary monuments which are plotted on his map. Stakes are driven at all lot corners not otherwise marked. All boundary lines, streams, roads, and permanent buildings are sketched and shown on the plan, and the names of the owners are written on their respective lots.

A notification of survey, printed in the native dialect, is given to each claimant, and an index card is prepared for each lot and signed by the claimant or his agent. In case of contested lots, such a card is filled out for each claimant. The sketchman assigns consecutive temporary numbers to the lots shown on his penciled map, and puts the same numbers on the corresponding index cards.

A sample index card as filled out by the sketchman is shown on page 26.

PLANE-TABLE METHOD. The plane-table method of sketching differs from the free-hand method in that plane-table traverses are run, and distances to stations and corners are obtained by means of a stadia and telescopic alidade. The equipment for such work is necessarily more extensive than that of the free-hand sketchman, and a party of six to ten men is required.

OFFICE WORK. After completing the sketching of all lots on a sheet, the sketchman brings his map, together with an index card for each lot, to the office. Here the lot boundaries are inked in black, excepting the boundaries of contested lots which are indicated by red ink. Permanent lot numbers are then assigned and placed upon both sketch sheet and index cards. A duplicate copy of each card is then typewritten and is later issued, with the sketch, to the surveyor.

IV. MONUMENTING.

The monumenting of lot corners proceeds in conjunction with, or closely after, the sketching. The monuments are of concrete, made by native labor during the time that the primary and secondary traverses are being executed. A 1:3:5 mixture is used, gravel and sand being obtained from the river beds. The size of monument in general use is 15 x 15 x 60 centimeters. They are cast in lots of ten, laying flat, and the letters $\frac{PLS}{BL}$ (Public Land Survey, Bureau of Lands) are imprinted on the heads by means of cast iron molds.

METHOD. Because of transportation difficulties it is necessary to make supplies of these monuments at various places throughout the project. They are then carried by laborers or by cart to the places where they are required. The monuments are set by gangs of six to ten laborers under the direction of a native foreman. The project chief usually indicates on the sketch the corners that should be monumented, and the foreman carries the sketch with him into the field. After setting a monument at a corner he places a circle around the corresponding point on the sketch. The number of monuments placed per day is dependent upon the distance the monuments have to be carried, but averages about two per laborer for the entire project. When the distances are more than a few hundred meters two men are required to carry each monument.

NUMBER REQUIRED. The rules at present in effect regarding the minimum number of monuments to be placed on each lot are:

Lot of 6 or less corners, at least 3 corners monumented;
" " 7 to 12 " " " 5 " "

Lot of 13 to 20 corners, at least 7 corners monumented;
" " 21 to 40 " " " 10 " "
" " 41 to 60 " " " 15 " "
" " 61 to 100 " " " 20 " "
" " more than 100 " " 1/5 of corners monumented.

Monuments in excess of this number may be placed when warranted by the character of the property lines, the size of lots and the number of corners per lot. In considering the number of corners of a lot, for the determination of the number of monuments required, those corners which lie along natural boundaries, such as streams and the seashore, are not counted excepting where the property first touches and leaves such natural boundary.

Fig. 8. Spike in a Cross on a Tree Used as Lot Corner.

Fig. 9. Getting Gravel from River Bed for Monuments.

Fig. 10. Monument Forms Assembled.

Note newly made monuments back of laborers.

Fig. 11. Lot Corner Monuments Ready for Distribution.

Sample card, numerical index

B. L. Form No. 77.

Cad. Survey No. 89 Case

NEGROS OCCIDENTAL Province Lot No.

(Coördinates Scaled.)

BINALBAGAN Munic. Cor. 1. { N. E.

Barrio Final sheet Sec.

Claimant Ced. No. , 191

P. O. Address

Spouse Living, Dead.

Agent

P. O. Address

Sketch by Date , 191 . Sheet No.

Claimant (agent) notified appeared Date , 191 .

Surveyed by Date , 191

Claimant (agent) notified appeared Date , 191 .

NOTE.—A card must be prepared for each claimant to this lot.

2—443

(OVER)

Numerical Index Card.

V. TERTIARY SURVEY.

The tertiary survey, or the survey of lot boundaries, is begun soon after the completion, in one part of the project, of sketching and monumenting.

EQUIPMENT AND PERSONNEL OF FIELD PARTY. The equipment of the field party usually consists of a Berger transit, two range poles, two or three stadia rods, two or three fifty meter or one hundred meter steel tapes, plumb-bobs for chainmen's use, a field umbrella, canteen, and leather field bag. The transits used in tertiary work are graduated to one minute of arc on horizontal and vertical circles, and are kept in their cases when not in actual use in the field. Range poles are of iron or wood two and one-half or three meters long, and stadia rods are three or four meters long with graduations to centimeters. Tapes are graduated to meters, are tested before being sent into the field, and the surveyor enters in his field notes, the constants for his chains.

The number of assistants required by the surveyor varies from ten to sixteen or more, depending upon the amount of vegetation in the section being surveyed and the distances between corners. Of these men, one is a lineman or foreman, two are rodmen, four are chainmen, two or three are stadiamen, one is instrument bearer, one carries the field umbrella, canteen and field bag, one is a card man, and others are bolomen and have miscellaneous duties. The amount and rapidity of growth of vegetation makes it necessary that each laborer provide himself with a bolo, a long, heavy knife carried in a sheath.

The surveyor obtains from the field office, or headquarters of the project, the sketch maps of the area he is to survey, notification and information cards for each lot on these sketches, and a copy of the primary and secondary azimuths of the project.

NOTIFICATION OF SURVEY. Before beginning the survey of the lots in a district, a notification card, printed in English and Spanish, is sent to each property holder or his agent, telling him when his lot will be surveyed and requesting him to appear at that time. Most of the blank spaces on these cards are filled out in the office, so that the surveyor is merely required to supply the intended date of survey before sending the card to the owner. A sample notification card is shown on page 36.

METHOD OF EXECUTION. The method of procedure of a tertiary party is, briefly, as follows: The surveyor sets the instrument over one primary or secondary monument, and having set the vernier at the correct azimuth, sights on the adjoining primary or secondary. He records the side shots to lot corners that can be obtained conveniently from the instrument, then sets, and moves ahead to, a tertiary station and backsights to the previously occupied station for azimuth, takes other side shots and proceeds as before.

Clamped azimuth is carried throughout the traverse and the vernier is reread after each backsight and checked with the foresight reading to that station. Some surveyors invert the telescope for the backsight, while others keep the telescope direct for all readings. When the latter method is used all azimuths read at alternate stations must be changed one hundred and eighty degrees

before being recorded. It is also a practice among some surveyors to repeat the backsight after taking the sideshots from a station immediately before foresighting to the next station.

For all shots to lot corners and stations the surveyor reads and records the stadia distance, azimuth, and magnetic bearing, and compares the azimuth with this bearing. The mark at each corner, as a monument, tree, post, rock, or stake is also recorded. The chain distance is checked against the stadia reading and recorded. Lot corners are designated in the note book by a fraction, the denominator of which is the lowest lot number at that corner, and the numerator is the corner number of that lot. On page 35 is shown a sample page of field notes.

Distances to all corners and stations are measured to the nearest centimeter. Each rear chainman records in his own book the distances which he secures and the marking of all corners, and at each station he gives his results to the surveyor from this record. In rough or rolling country vertical angles are required for many of the measurements.

It is the duty of the lineman to find, with the assistance of the lot owners, the corners approved by them, and to put the tertiary stations in places most convenient for shooting these corners. Under the direction of the surveyor, he manages the field party, verifies the information shown on the sketch map, reports discrepancies and contested boundaries to the surveyor, and acts as interpreter if the surveyor is not familiar with the native dialect. The progress of the field party depends largely upon the capability of the lineman.

The cardman assists in notifying the lot owners and obtains, on the survey record card of each lot, the owner's signature to the statement that he conforms to the boundary as surveyed. The cards, when completed, show when and by whom the lot was surveyed, whether or not the owner appeared and conformed with the boundary lines, his name and address, and the cadastral number and location of the lot. A sample index card as completed by the surveyor is shown on page 36.

MARKING OF LOT CORNERS. All corners are marked in some way, if only by a stake, and the general absence of fences makes the use of monuments a necessity. Trees are marked by driving a galvanized iron spike in a cross or blaze, and rocks are chiseled with the letters $\frac{PLS}{BL}$.

BALANCING THE TRAVERSE. Station numbers are assigned from one consecutively throughout the project, and as several surveyors are working at the same time, each surveyor is assigned a thousand numbers for his own use. Tertiary traverses begin on primary or secondary stations, and a closure is made on such a station whenever the course of the work brings the traverse near to one of them. The length of a tertiary traverse depends upon the size of parcels, but is usually between one and five kilometers. The required accuracy does not admit of an error of closure exceeding $1/63\sqrt{P}$, where P is the length of the traverse. In the survey of one project containing 25,000 hectares and 1900 lots, 243 traverses were run. The average length of traverse was 3300 meters and the average error of closure was one in nine thousand seven hundred. The length of

sideshots and stations is dependent upon the size of lots and the and the nature of the country, though ordinarily station distances exceed forty meters and sideshots are less than two hundred meters.

Upon the completion of the survey of a sketch sheet, it is returned to the office with the field notes and information cards for that sheet. The traverses are computed and any which fail to close within the required limits are returned to the surveyor for correction. The surveyor seldom needs to spend more than two days per month on traverse correction.

MONTHLY RATE. The area surveyed per month by single field parties varies from 4000 hectares in large lots in open country to less than 500 where lots are small. An average output of 1400 to 2000 hectares per month is obtained in the sugar district of the island of Negros. The size of lots, topography, amount of vegetation, correctness of sketch maps, intelligence of property holders, and the energy of the surveyor are factors affecting the output.

PREVIOUSLY SURVEYED PROPERTIES. When, in the course of his work, the surveyor encounters property, a survey of which has previously been made by, or approved by, the Bureau of Lands, he makes an effort to relocate the boundaries of the former survey, and for this purpose he carries into the field, a plan of the former survey. In cases where the old corners can not be found, or where the claimants indicate different boundaries, a survey is made of the new lines as shown. The new and old surveys are then compared in the office and the claimant to the previously surveyed property is notified of the differences, if any exist.

It is considered best to accept without alteration, whenever possible, the plan and computation of former surveys, and the surveyor is often sent back into the field, with comparative plans of his own and the former surveys, in an effort to find and secure the agreement of claimants to the old corners. The use, in the execution of these former surveys, of an insufficient number of boundary monuments and a lower degree of accuracy than that now required makes this relocation quite difficult and expensive.

DIFFICULTIES ENCOUNTERED. Many difficulties encountered by the surveyor are due to conditions peculiar to the character of the people and their country. Practically no fences are in existence, and on this account the actual presence of all interested owners or their agents is necessary before the corners can be located. In many cases the owners have never tried to come to an agreement as to the exact location of their boundary lines, and disputes often arise which cause much delay to the survey party, since one of the surveyor's duties is to settle, on the ground, as many as possible of the disputes, in order to avoid expensive adjudication in the courts. Many of the claimants are ignorant of the importance of indicating to the sketchman and to the surveyor their exact boundaries, and do not understand that boundary lines must be straight from one corner to the next. The survey party is often kept waiting while some claimant finishes his "siesta" or takes a meal, which operations are considered more important than looking after the boundary questions. This is quite irritating, especially to American surveyors, because meals are eaten at almost

any hour of the day, and the Filipino has an inborn antipathy to disturbing anyone who is eating or sleeping.

In the rainy season considerable time is lost because of the difficulty of travelling to and from work, and because little progress can be made during a rain. This feature is more important in some parts of the Islands than in others because of the difference in amount and distribution of rainfall. In Negros the total time lost does not amount to more than ten days per year, and the surveyor is in the field practically every day in the year excepting Sundays and holidays.

As all land claimed by individuals is surveyed, some of the work is done in districts which are wild and sparsely populated, and the distance from headquarters makes it necessary for the surveyor to live in the various native houses nearest to his work. The use of tents is seldom required. The danger of encountering wild animals and snakes is small, but quite often whole survey parties are attacked and routed by swarms of bees. Such attacks are quite serious on account of the difficulty of escaping from them in the deep log-filled ravines where much of the hill work is done. Their ferocity is indicated by the fact that they follow, for perhaps a mile or more, the persons whom they attack. During about one month of the year, just after the rainy season begins, field work is made very unpleasant by millions of little sharp-biting gnats, which thrive best in the tall grass of the uncultivated fields.

Both banks of all streams are surveyed, and it is in the execution of these stream surveys that the field party meets with the greatest difficulty because of the luxurious growth of trees,

grass, weeds and vines. One grass, called "tigbao", grows to a height of ten to twenty feet, and the growth is often so dense that one can go through it only after cutting a passage.

The months of January, February and March are most favorable for field work. At that time the heat is not oppressive and there is little rain, the rice fields are no longer flooded, cane fields are being cleared, the heavy grass is burned, and roads are easily passable. Work in the swamps and timber is difficult at any time.

over

B. L. Form No. 94a.

SKETCHES, DESCRIPTIONS, AND REMARKS.

40

Corrected Azimuth.	Corrected Distance.	

It is reserved for binding.

over

Sample Page of Tertiary Notes.

Sta. Occupied.	Sta. Observed.	Stadia Distance.	Assumed Azimuth.	Chain Distance.	Magnetic Bearing.	Vertical Angle.

B. L. Form No. 94a. Sample page of tertiary notes

SKETCHES, DESCRIPTIONS, AND REMARKS.

Corrected Azimuth.	Corrected Distance.	

It is reserved for binding.

Sample Page of Tertiary Notes.

Sample index card, alphabetical

B. L. Form No. 77.

Cad. Survey No. 89 Case

NEGROS OCCIDENTAL Province Lot No. 764

(Coördinates Scaled.)

BINALBAGAN Munic. Cor. 1. { N. E.

Santa Rosa Barrio Final sheet 96 Sec. B

Claimant Juan de la Cruz Ced. No. F19667, 1914

P. O. Address Buenavista, Binalbagan, Neg. Occ.

Spouse Regina Lalakad Living, ~~Dead~~.

Agent Felipe Juan F 997664 - 1914

P. O. Address Santa Rosa, Binalbagan, Neg. Occ.

Sketch by F. Barron Date Jan. 12, 1915. Sheet No. 96B

Claimant (agent) notified yes appeared yes Date Jan. 12, 1915.

Surveyed by Date , 191

Claimant (agent) notified appeared Date , 191 .

NOTE.—A card must be prepared for each claimant to this lot.

2—443

(OVER)

Alphabetical Index Card.

Sample notification card

B. L. Form No. 104-a.

Sketch Sheet No. 96 B Lot No. 764

No. del croquis Lote No.

Binalbagan, Neg Occ P. I.

I. F.

Feb 24, 1915

Juan de la Cruz

You are hereby notified, in accordance with section 2 of Act No. 2259, that the property claimed by

Por la presente se le notifica que de acuerdo con el artículo 2 de la Ley No. 2259, la propiedad reclamada por

You designated as lot 764

designada como lote

Sheet 96 situated in the barrio of Santa Rosa adioining that of

Croquis situada en el barrio de colinda con el de

Andres del Monte and others, will be surveyed by the undersigned on

y otros, será medida por el que suscribe el

Feb 27, 1915. As claimant thereto and in accordance with the provisions

Como demandante a ella y de acuerdo con las provisiones

of section 4 of Act No. 2259, you are requested to appear on the ground on Feb 27, 1915,

del artículo 4 de la Ley No. 2259, se le encarece a que comparezca en el terreno el

at 8 4 m., and make such objection to the boundaries of the property to be surveyed as may be

las y hacer las objeciones que consideren necesarias a los linderos de la propiedad que se ha

considered necessary for the protection of your rights. In making inquiries present this card to the undersigned, also

de medir para la protección de sus propios intereses. Al hacer los informes preséntese esta tarjeta al que suscribe y

to the Court of Land Registration with your application for registration of title.

también al Tribunal del Registro de la Propiedad con su solicitud para el registro de título.

John Doe

Surveyor, Bureau of Lands.

Agrimensor del Buró de Terrenos.

2—444

Notification of Survey Card.

Fig. 12. Field Office, Head-quarters for Project Survey.

Fig. 13. Surveyor's Temporary Field Quarters.

Fig. 14. Going to Work.

Fig. 15. Tertiary Party.

Pictures below show a tertiary party at work. Frequent rains alternate with hot sunshine and make an umbrella a necessity. The chainmen are continually working near the instrument, but seldom disturb it.

Fig. 16.

Fig. 17.

Fig. 18. View in Rice Country with Bamboo in the Background. The entire area is flooded, and fields are separated by dikes.

Fig. 19. Sugar-cane Spread Apart for Tertiary Traverse Line.

Surveys are expensive in the hills, where the value of land is small. Wild banana plants and cogon grass cover areas that are deforested and uncultivated, and the deep ravines are filled with trees, logs, and dense undergrowth. Surveys are made of small, isolated claims far up on the mountain sides.

Fig. 20

Fig. 21.

Tertiary work in forested lands is difficult, but most interesting because of the strange and beautiful forms of plant and animal life encountered. Monkeys frequently inspect the surveying party, and from the tree-tops give voice to their disapproval of the of the trespassers upon their ancestral domains.

Fig. 22.

Fig. 23.

VI. POLITICAL BOUNDARIES.

The Philippine Islands are divided and subdivided, politically, into provinces, municipalities, and barrios, which correspond in a general way to the states, counties, and townships of the United States. One of the duties connected with the cadastral survey is to determine and monument the boundaries which separate these political divisions.

LOCATION. From the time the survey of the project is begun until it is nearly finished, the project chief is forced to combat the inertia of the municipal and provincial authorities in ascertaining the location of these boundary lines. In practically none of the municipalities has a previous exact determination of the municipal lines been made, and in order to locate them it is necessary that representatives of the adjoining municipalities accompany the surveyor in the field. As this involves considerable physical discomfort to those concerned, it frequently happens that the representative delegated by the municipal authorities is a policeman, who knows little or nothing about the actual location of the boundary, and who has no power to settle disputes. Usually all questions of this nature which arise are settled, after months of effort, by the slowly moving municipal councils. A failure of settlement in this way necessitates the submission of the dispute to the provincial authorities, which results in another delay of a few months.

While the settlement of the municipal boundary is in progress, pressure is being exerted on the municipal authorities to determine the internal divisions, or barrio boundaries. This determination is often difficult because the average Filipino's idea

of a barrio is a village, and not an extension of land.

MONUMENTING. After the location of these lines is finally agreed upon, concrete monuments are built marking the corners. Three different sizes of monuments, shown in the accompanying pictures, are in use at provincial, municipal, and barrio corners. The names and corner numbers of the political divisions which meet at each corner are placed on the monuments.

Wooden forms, made in four parts and firmly built so that they may be used repeatedly, are employed in the construction of boundary monuments. Lead letters and numbers are attached at their proper places, the form is assembled and bolted together, and is then set over the hole previously dug for the base. Gravel, sand, and water are obtained from the nearest stream, and the cement is carried by laborers from the nearest point to which a cart can bring it. A spike is placed in the top of each monument, and from it radiate lines toward similar adjacent monuments. These monuments are very satisfactorily constructed by a Filipino foreman with a gang of eight or more laborers. After they are constructed, their position is accurately determined by the surveyors, and references for their future location are taken to permanent nearby objects.

Fig. 24. Provincial Monument Form.

(1.20 meters high)

Fig. 25. Provincial Monument.

Fig. 26. Municipal Monument.

(90 centimeters high)

Fig. 27. Barrio Monument.

(80 centimeters high)

VII. THE FIELD OFFICE.

The field office performs all of the office functions necessary for preparing the cadastral survey for the court, with the exception of computing areas, tracing and blueprinting the final map sheets, and writing the technical descriptions of the individual lots.

PERSONNEL. The office personnel, for a project of ordinary size employing three or four surveyors in the field, consists of the surveyor in charge of the project, a Filipino surveyor in direct charge of the office, two draftsmen, four checkers, five computers, and one cardman. The draftsmen and checkers are also employed at computation part of the time.

OFFICE FUNCTIONS. While work is beginning on a new project, the office force is engaged in the preparation of map and sketch sheets, and index and progress maps. Area sheets are numbered and bound in books of one hundred and fifty sheets, and previously surveyed properties are plotted on the sketch sheets. As the field work progresses the office men are occupied with the computation of primary and secondary traverses and the inking and numbering of lots on the sketch sheets. The cardman typewrites duplicates of the cards received from the sketchmen and prepares notification cards for use by the surveyor.

As most of the time of the office force is spent in drafting and computing the tertiary field notes, the best way to get an idea of the office work is to follow a book of such notes through its various courses.

The surveyor sends to the project chief, the field notes together with sketch sheets and cards. The surveyor in charge of

the office then balances the angular error of closure of each traverse, and turns the notes over to the computers, who make duplicate, independent computations of all traverses. Latitudes and departures are obtained by multiplying the corrected chain distances by the natural cosines and sines of true bearings on computing machines. The two results are then compared and any errors corrected. A computation is then made of the lineal error of closure, and if this is within the required limit, the error is distributed and the station co-ordinates are computed.

One of these traverse sheets is then given to the draftsman who plots the traverse stations on the final map, by co-ordinates, and checks his work by referring to the azimuths and distances of different courses. After this operation is completed, he plots all of the side-shots to lot corners with the aid of a Universal drafting machine, connects the corners with the aid of the sketch sheet, and assigns lot corner numbers on the map sheet and also in the note book if this has not already been done by the surveyor in the field.

The notes and traverse sheet are then returned to the computers who copy, on the original area sheets, the side-shots to lot corners, and compute the co-ordinates of these corners by obtaining latitudes and departures with the aid of a computing machine. Lots which have more than thirteen corners require the use of additional area sheets.

The notes, penciled map and original area sheets are then turned over to the checkers, who, working in pairs, compare the corner co-ordinates scaled from the map sheet with the computed co-ordinates in the area book, and correct, by referring to the

note book, any errors which they may find. This check serves only to pick up gross errors made in plotting or computing the co-ordinates of lot corners.

A tracing is made at this time of the final map sheet, and the tracing is taken into the field for verification by a different sketchman from the one who originally sketched that sheet. He goes over the lot boundaries with the owners, and notes on the tracing any incorrect connecting or marking of lot corners. While this procedure is not in general practice in all cadastral parties, experience has demonstrated that the number of errors avoided amply justifies its continued use.

The map sheet is then inked, lot lines being made black, traverse lines red, and stream lines blue.

Duplicate area sheets have, in the meantime, been computed, and are now compared with the original area sheets, and errors are corrected. The lot corner co-ordinates on these duplicate area sheets are then compared with the scaled co-ordinates of the inked map to pick up any errors in inking. This third check completes the traverses, area sheets, and map sheets as far as the lot boundaries are concerned. Barrio names and other details are supplied later. Since the field notes are continually coming in to the office during the time of the tertiary survey, they are to be found in the office in all stages of completion.

Tie lines are computed, on the area sheets, from the nearest provincial, municipal, or barrio monument to corner number one of each lot. These tie lines may not exceed two kilometers in

length, and in case there is no such monument within that distance from a certain district, location monuments are built for this purpose, and tie lines are computed from them.

It is the duty of the surveyor in charge of the project to apportion all field and office work among the employees. He is the paymaster for the entire native force, excepting the civil service employees, and the disbursements average about one thousand dollars monthly for a project. Much of his time is occupied in comparing the results of the cadastral with previous surveys. Since titles have been issued for many of these former surveys, it is necessary to make the cadastral survey agree, as nearly as possible, with the old. The cadastral surveys would be more easily and economically executed had no surveys been made previously.

The cards which are turned in by the sketchmen are kept in a filing cabinet in numerical order, while those returned by the surveyor are filed in the alphabetical order of the names of lot owners. Thus, upon the completion of the project, there are, in the office, two cards for each lot, one bearing the signature of the owner or his authorized agent to the statement that the sketching and monumenting was correctly done, and the other a similar signature to the statement that the correct boundaries were shown to the surveyor.

These cards are later used by the court to facilitate the decreeeing of properties, and as records of the fact that the claimants were properly represented at the time of the survey.

In addition to the regular map sheets, the draftsmen prepare on a similar sheet, and keep up to date, an index map of

the project, usually made to a scale of one in 30,000. On it are shown map sheet and co-ordinate lines, the boundaries of the project and the barrio divisions, primary and secondary stations, roads, streams, haciendas, and a table showing the work performed each month.

A progress map, which is a tracing of the index map, but which shows, in addition, two miniature plans of the project to a scale of 1:150,000 or 1:200,000, is also prepared. At the end of each month the area sketched and surveyed are shown by cross-hatching on these smaller plans. The progress map is then sent to the Manila office, where it is inspected, blueprinted, and returned to the surveyor. The exact status of the work is thus made known each month to the Chief Surveyor in the Manila office.

A monument book is also prepared by each project, giving, on loose leaf forms sufficiently thin for blue-printing, descriptions, locations, and references of all primary, provincial, municipal, barrio, and location monuments.

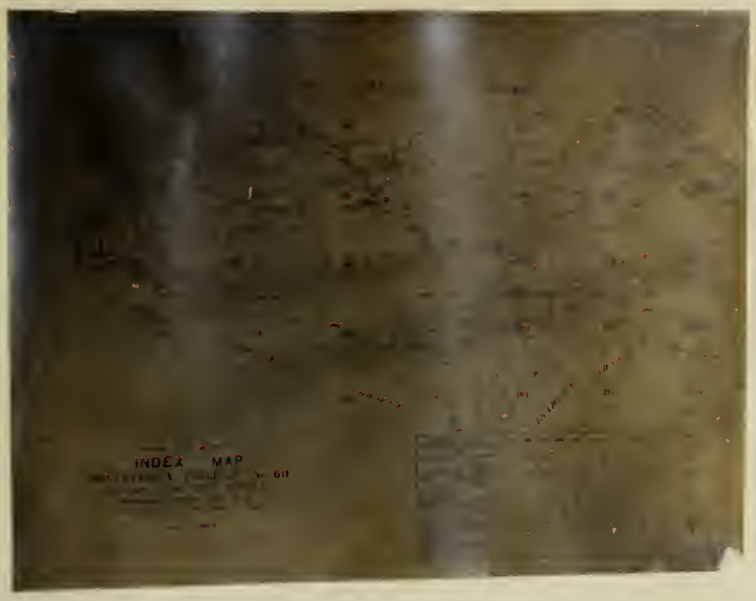


Fig. 28. Index Map.

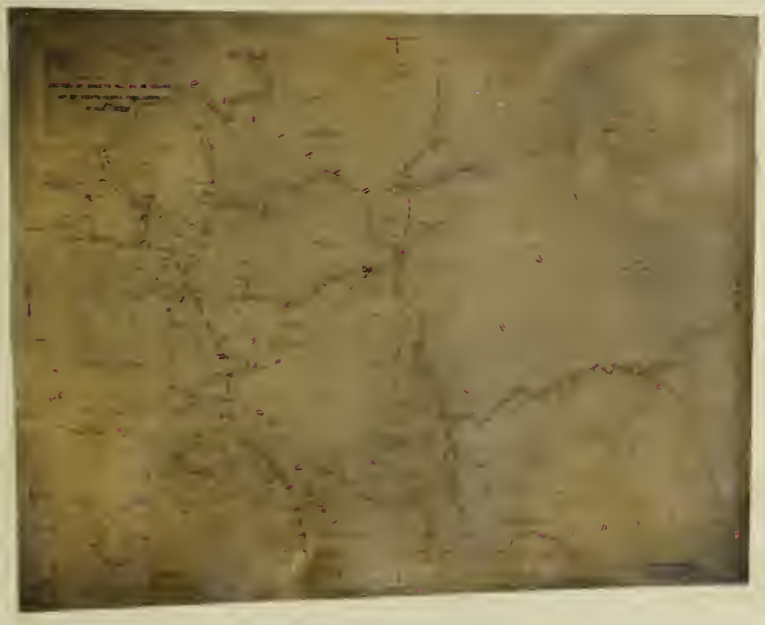


Fig. 29. Map Sheet.

B. of L. Form No. 17 A.

TRAVERSE SHEET.

Surveyed for ..... *B. of L. No.* .....

Municipality ..... *Case No.* .....

Province ..... *Sheet No.* .....

NOTE.—Case No. to be used in Cadastral Surveys.

2—426

1	2	3	4	5	6	7	8	9
							82	

Sample tertiary traverse computation

Columns 1, 2, 3, and 4 copied by ..... *Date* ..... , 191 *Compared and final check*

Columns 5, 6, 7, and 8 computed by ..... *Date* ..... , 191 *by* .....

Column 9 computed by ..... *Date* ..... , 191 *Date* .....

TRAVERSE SHEET.

Surveyed for ..... B. of L. No.

Municipality ..... Case No.

Province ..... Sheet No.

NOTE.—Case No. to be used in Cadastral Surveys.

1	2	3	4	5	5	7		8		9	
Note Book No.	Page No.	Station	Azimuth Distance. Bearing.	Log. Distance Log. Cos Bearing. Log. Latitude.	Log. Distance Log. Sin. Bearing. Log. Departure.	Latitude. North.	Latitude. South.	Departure. East.	Departure. West.	Coordinates. Northings.	Coordinates. Eastings.

Sample tertiary traverse computation

Columns 1, 2, 3, and 4 copied by ..... Date ..... 191 . Compared and final check

Columns 5, 6, 7, and 8 computed by ..... Date ..... . 191 by .....

Column 9 computed by ..... Date ..... . 191 Date .....

B. L. Form No. 18

BUREAU OF LAND MANAGEMENT

B. of L. No. _____

Lot No. _____

Sheet No. _____

Old Registration No. _____

2 825

Tract Book.	Page.	3 Traverse Station. Occupied.	FIELD. M. D. Latitude. Double Area.	AREAS. 18 N. Double Area.	19 S. Double Area.
		5112			
23	5				
		"			
		"			
		"			
"	"	"			
16	4	5216			
"	"	5215			

B. L. Form No. 18-B.

BUREAU OF LANDS AREA SHEET.

Application of _____ Surveyed by _____ Date _____ B. of L. No. _____

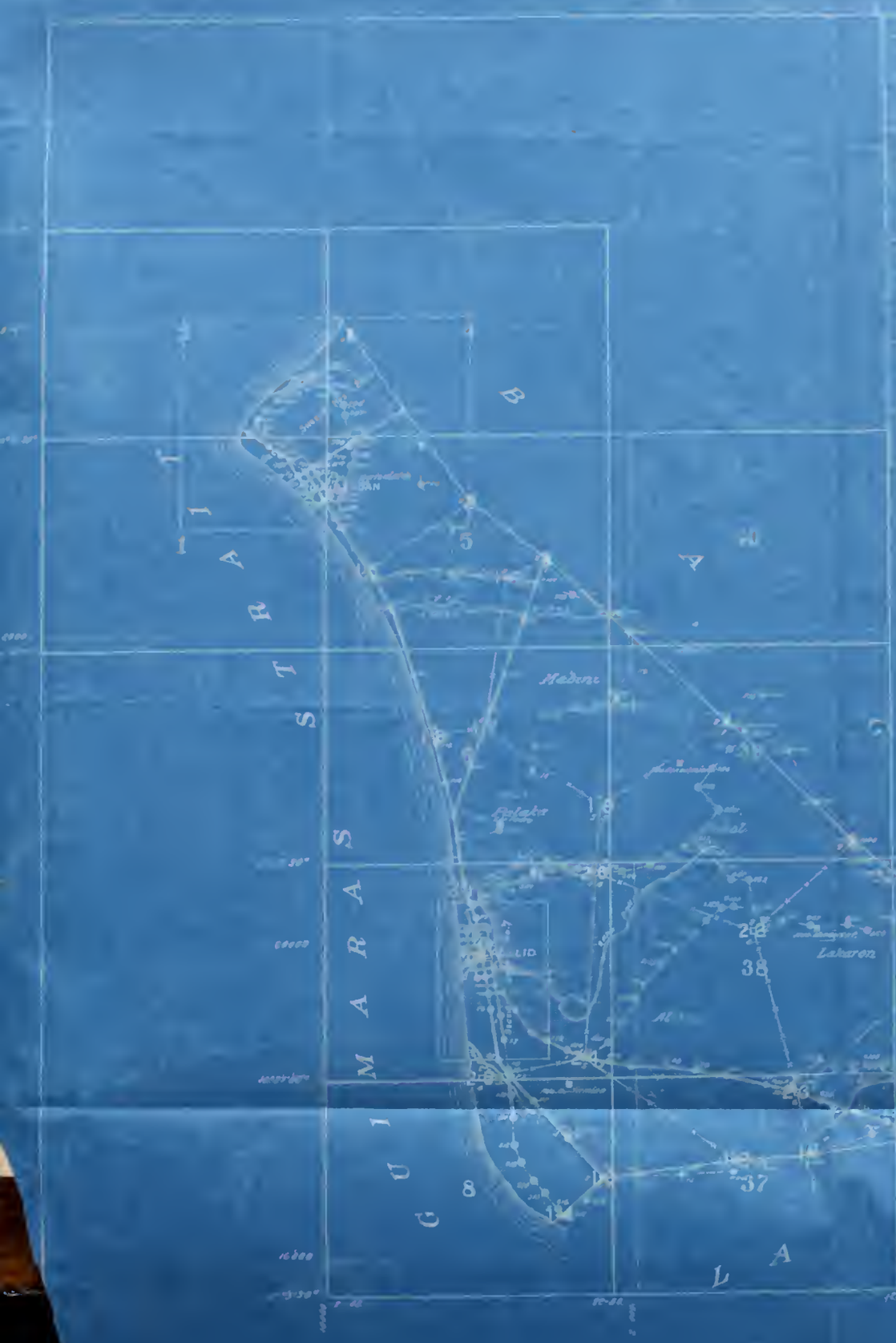
Barrio of _____ Municipality of _____ Lot No. _____

Province of _____ Island of _____ Sheet No. _____

Classification of Survey _____ Index Sheet _____ Court of Land Registration No. _____

Tract Book.	2 Page.	FIELD DATA. 3 Traverse Station. Occupied.	4 Station Observed.	5 Azimuth. Distance. Bearing.	6 Log. Distance. Log Cos. Bearing. Log. Latitude.	7 Log. Distance Log. Sin. Bearing. Log. Departure.	COORDINATES. 8 Latitude. Northings.	9 Departure. Eastings.	10 Line.	11 Latitude. North	11 Latitude. South	12 Departure. East	12 Departure. West	13 Log. Departure Log. Latitude. Log. Tan. Bearing.	14 Log. Departure. Log. Sin. Bearing. Log. Distance	15 Bearing. Distance.	16 Double Meridian Distance of Side.	17 Log. D. M. D. Log. Latitude. Log. Double Area.	AREAS. 18 N. Double Area	AREAS. 19 S. Double Area.

AREA SKETCHED



PRIMARY SURVEY	MON.		OCT.	NOV.			FEB.	MAR.
	1							
	5							
	7							
SECONDARY SURVEY								
	09							
	FT316	39304		9				
	7	9						
TERTIARY SURVEY								
"Sketched"								
Farm	Gd							
Meanders	08							
Dups	7							
	66		1921	8				
			96	1				
	66	394	790					
		183						
			358	748	7			
		10		4980				
Traverse		67		PRETO				
		683	3390	3674				
		28	72	78				
		2		1				

POLITICAL BOUNDARIES

AREAS SKETCHED

PROGRESS MAP
VALLADOLID CADASTRE

B.L.No. 42

VALLADOLID NEGROS OCCIDENTAL, P.I.

SURVEYED BY SURVEY-PARTY No 19, BUREAU OF LANDS.

August, [illegible]- February

SCALE OF 1 30000.

VIII. GENERAL INFORMATION AND COSTS.

PROJECT PERSONNEL. The personnel required on a project of ordinary size consists of the surveyor in charge, about twelve office men, three or four surveyors, two to four sketchmen, about eight foremen, and from fifty to one hundred laborers. The surveyor in charge is generally an American, while the men working under him are usually all Filipinos. Heretofore most of the instrument work in the field has been done by Americans, but the present tendency is to fill such positions with Filipinos whenever possible, so that now nearly all of the field work is done by them.

The Bureau of Lands maintains a school for surveyors in the Manila High School, and graduates from a two-year course are given a probational appointment as Junior Surveyors in the Philippine Civil Service provided they pass the examination. They receive an entrance salary of twenty-five dollars per month and field expenses, but are later required to take the civil service examination for surveyor if they desire to remain in the service. Their salary becomes fifty dollars per month and field expenses after receiving an appointment as surveyor. Their salary after this time depends upon their efficiency and length of service. There are now about fifty Filipino surveyors in the Bureau, and while many of them are as yet incapable of holding executive positions their work is quite satisfactory in subordinate positions.

The laborers come from the poorer classes, and most of them are between sixteen and twenty-five years of age. Few of them have received an education beyond one or two years in the public schools, and many have never attended any school. The more intelligent of these laborers develop into chainmen, linemen, and

sketchmen. There are but six or eight men, surveyors and computers, on each project who have carried their education into the high school, and the general lack of education among foremen and laborers makes necessary a close supervision of their work.

The wages paid to assistants vary from twenty-five cents per day for laborers to $1.20 for foremen and sketchmen. The average daily rate of office men is about $1.00. The office force works seven or seven and one-half hours each day except Saturday, which is a five hour day. There are no regular hours for the field men, since their working time depends upon the distance from living quarters, weather, etc. Usually conditions admit of more than eight hours of actual work.

COSTS. The time required to complete the survey of a cadastral project is usually a little less than one year, and the cost of the completed survey varies from about $8.00 per hectare where holdings are small to less than $1.00 among large parcels. This cost is affected also by widely differing local conditions, such as labor prices, transportation facilities, topography, rainfall, etc. The following table shows the items of expense and the amount devoted to each in the survey of a project containing large holdings:

Item of Expense.	Cost per hectare.
Primary traverse	$ .10
Secondary traverse	.03
Sketching (Free-hand), and Investigation	.04
Lot monumenting (at 25 cents each in the ground)	.05
Municipal boundary monuments ($8 each)	.02
Barrio boundary monuments ($3 each)	.01
Tertiary survey	.25
Field administration and field office	.25
Manila office (estimated)	.10
Total cost per hectare.	$ .85

GENERAL INFORMATION. Another table follows showing the size and number of parcels in several projects which have already been surveyed:

Area of project	Number of lots.	Average size of lots.
12,500 hectares	3000	4.2 hectares
10,000 "	4500	2.2 "
8,500 "	3800	2.2 "
38,000 "	2200	17.3 "
25,300 "	1920	13.2 "
18,000 "	900	20.0 "
17,000 "	1600	10.6 "
16,000 "	850	18.8 "

The irregularity of shape of the lots is indicated by the following figures relative to the sixth project in the above table: 1920 lots; average size, 13.2 hectares; 18,900 corners; 14.6 corners per lot. It can readily be seen that the cost of survey is higher, because of this relatively large number of corners, than it would be in places where the U. S. system of rectangular land surveys has been introduced.

Upon completion of the field and office work in a project, all records are sent to Manila to the Bureau of Lands, together with the final report of the project chief concerning the work on his project. Here the survey is prepared for adjudication, the Bureau retaining, in its archives, the final records of the survey.

IX. SUMMARY.

The following criticisms on the execution of cadastral surveys are offered:

Unjustifiable accuracy is required in the closures for primary, secondary, and tertiary traverses.

There is needless refinement in the survey of streams.

Every corner not otherwise permanently marked should be monumented.

Roads are constructed and maintained by the Bureau of Public Works, but the properties through which they run are surveyed by the Bureau of Lands. There is need of co-operation between the local offices of these two Bureaus in order that the roads may be properly excluded from the lands through which they run.

Since a large proportion of the errors in the survey are due, not to inaccurate measurement, but to failure on the part of the owners to show their true boundaries, the investigation of boundaries from tracings of the final maps, described under "The Field Office", should be in general use.

The practice of having one of the sketchman's assistants accompany the surveyor, in order to expedite the relocation of lot corners, should be discontinued, because it permits the survey of the land without the actual presence of the owner and leads to inaccurate location of boundaries.

The segregation of costs is not complete enough to admit of a careful study and supervision of the various items of expense. The costs are at present segregated as follows:

"Item No. 1", Triangulation.
"Item No. 2", Primary and secondary traverse, including the cost of monumenting the political boundaries.
"Item No. 3", Tertiary survey, including sketching, monumenting, tertiary and investigation.
"Item No. 4", Administration, including all office work.

A better segregation would be as follows:

"Item No. 1", Triangulation.
"Item No. 2", Primary traverse.
"Item No. 3", Secondary traverse.
"Item No. 4", Determination and monumenting of political boundaries.
"Item No. 5", Sketching.
"Item No. 6", Monumenting of lot corners.
"Item No 7", Tertiary survey.
"Item No. 8", Investigation.
"Item No 9", Field office, (This could be further segregated.)
"Item No.10", Administration

The accuracy required in the execution of cadastral surveys is equal to that used in the survey of cities in the United States, and in many cases the cost of the survey exceeds the value of the land being surveyed. By monumenting every corner not otherwise marked and by executing a plane-table survey, results could be obtained sufficiently accurate for agricultural lands and small towns, and at less than one-third of the cost of the present system. There are probably not a dozen cities in the Islands where such a survey would not suffice and these could be covered by more accurate surveys. Areas could be obtained by the use of a planimeter.

Many of the existing defects here enumerated could be eliminated were there a closer acquaintance of the managing officials of the Bureau with actual field conditions. Field parties are seldom, if ever, visited by inspecting surveyors or by the higher officials of the Bureau.

UNIVERSITY OF ILLINOIS-URBANA
3 0112 082198406